HANSEN

Mortar Making Qualities of Illinois Sands

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MORTAR MAKING QUALITIES OF ILLINOIS SANDS

BY

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THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

1912

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COLLEGE OF ENGINEERING.

May 24, 1912

This is to certify that the thesis of VIGGO HANSEN entitled MORTAR MAKING QUALITIES OF ILLINOIS SANDS was prepared under my personal supervision; and I recommend that it be approved as meeting this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

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TABLE OF CONTENTS.

		Page
I.	Introduction	1
II.	Description of Tests.....	3
III.	Description of Sands	5
IV.	Discussion	7
V.	Description of Tables	9
VI.	Tables	
VII.	Sieve Analysis Curves	

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INTRODUCTION.

Owing to the enormous increase in the use of concrete during the last few years, and also to the many varied forms in which it is used, much thought has been given to the study of the component parts; in particular to the cement and the coarse aggregate. Many experiments have been conducted to determine those things; while very little study has been devoted to the sand.

Recently, however, many experiments have been made to determine the effect of the sand on the quality of the concrete, and since concrete may be said to consist of a mortar and a coarse aggregate, the characteristics of the sand are most easily and effectively studies by determining its effect on the quality of a mortar. And further, there is a growing demand for more definite information concerning the value of particular sands for use in mortar or concrete.

In view of these facts, the writer has undertaken a series of tests upon six natural sands of the State of Illinois; four from near Morris, one from Joliet, and one from East St.Louis; to determine their mortar making qualities and to secure if possible any light on the mortar making characteristics of sands in general. Ottawa standard sand was also included for the purpose of comparison.

The four samples from Morris were collected under the writers directions, and were taken in such a manner as to

be representative of the pit, and shipped to the laboratory in separate paper lined boxes. The Joliet and East St. Louis sands were collected by other parties, but in a similar manner.

DESCRIPTION OF TESTS.

TENSILE STRENGTH.

The tests were conducted according to the specifications of the American Society of Civil Engineers. "Chicago A. A." cement from a single sack, purchased on the local market, was used. A normal plasticity test of the cement required 21 percent water and accordingly 9.5 percent was used for the mortars, with the exception of the Ottawa sand where 9 percent was used.

The mixing and molding were done on a slate topped table. Molds of standard dimensions were used, and filled in three increments. A set of six briquettes were made from each mixing and three sets from each sand; a total of eighteen briquettes from each sand. The briquettes were left in the molds covered with a damp cloth and metal cover for twenty-four hours; after which they were stored in running water, maintained at approximately seventy degrees Fahrenheit, until tested. Six briquettes, two from each set, were tested at the age of seven, twenty-eight, and ninety days, respectively, in a Riehle automatic testing machine, applying the load at the rate of six hundred pounds per minute.

CLEANNESS.

The foreign material usually found in sand is clay

and loam. In order to remove this, a known weight (usually one-thousand grams) was put in a glass jar of about six quarts capacity, and the jar then filled with water. After stirring thoroughly for a short time, the mixture was allowed to settle for about one minute. Then the dirty water was drawn off by means of a quarter inch siphon; care being taken not to carry any of the fine sand over with the water. This process was repeated until the water was practically clear. The water was then drained off, and the sand placed in a pan, and after being thoroughly dried over a steam coil, it was reweighed. The loss in weight gave the weight of suspended matter, which was reduced to a percentage of the original weight of sand. The sand from East St. Louis was not washed, since it contained practically no clay or loam.

FINENESS.

The fineness test was made as follows:

A known weight(usually one-thousand grams) was screened through a nest of seven sieves (Numbers 5, 8, 16, 30, 60, 100, and 200) by shaking it for forty minutes on a Per Se Testing Sieve Agitator at the rate of 100 R.P.M. After being shaken, the amount retained on each sieve was weighed and the percentage passing each sieve determined. There was a slight loss in most of the sands but this was probably all fine material. and was considered as passing the 200 sieve, and the suspended matter was also included with the material passing this sieve

in computing the percentages.

DESCRIPTION OF SANDS.

NO. 18. JOLIET SAND.

The sand from Joliet is a very fine bank sand (99 percent passing the 30 sieve). It is a brownish yellow, resembling granulated clay, and consists largely of a soft stone which has been ground, or hard clay. It contains a considerable amount of suspended matter (9.5%), principally clay. It formed the weakest mortar, a 1:3 mixture showing a strength of only 165 pounds per square inch at ninety days.

NO. 51. EAST ST. LOUIS.

The sand from East St. Louis is taken from the Mississippi River, and is a very clean and hard sand. It is composed almost entirely of silica and very nearly of one size. It resembles the Ottawa standard sand in many respects (except sharpness), and formed the strongest mortar when the standard sand is not considered. The strength at ninety days was 273 pounds per square inch. It contained practically no suspended matter.

NO. 101. MORRIS (GRIGGS).

The Griggs sand from Morris is from a pit situated between the Illinois and Michigan Canal and the Illinois River in the city. It is of the usual brownish color of bank sand. It contains too many grains passing the 30 sieve and retained on

the No. 60. It had only 1.54 percent suspended matter, and 1:3 mortar tested 242 pounds per square inch at 90 days. The grains were fairly hard but with an occasional soft one.

NO. 102. MORRIS (PEACOCK).

The Peacock sand from Morris is taken from a pit north of the Illinois River and two miles east of town. It also has too many grains retained between the No.30 and No. 60 sieves. It is a brownish yellow, and yet does not contain much clay; the suspended matter amounting to only 1.5 percent. It is fifth in rank with regard to tensile strength; a 1:3 mortar testing 202 pounds per square inch at 90 days.

NO'S. 103 and 104. MORRIS (NICHOLS AND BRAUN).

The Nichols and Braun sands also from Morris are very similar although the pits are on opposite sides of the river, and are about four miles apart. The percent. of suspended matter of No. 103 was 4.01 and of No. 104, 4.25. In strength they are equal, the tests showing 257 and 256 pounds per square inch, respectively. They are very similar in appearance, and appear to be dirty. The grading approaches the ideal uniform grading so closely that the disadvantage of the foreign material is overcome to a great extent. They follow very closely after the East St. Louis sand in tensile strength, although they differ widely from it in composition and suspended matter.

DISCUSSION.

It can easily be seen from the results given herein, that no one test gives conclusive evidence of the quality of the sand for use in making mortar. Cleanness plays an important part, and yet a clean sand if not well graded often makes a poor mortar. An example of this is No. 102. It contained only 1.5 percent suspended matter, and yet ranked fifth in strength. The East St. Louis sand on the other hand, while being very clean, and yet not as well graded as No. 102, formed the strongest mortar tested; while the 103 and 104 sands which were comparatively dirty, but well graded, yielded mortars of considerable strength. The Joliet, No. 18, sand, was very dirty and poorly graded, and so naturely was the weakest in tensile strength. No. 101 is a fair sample of sand. It did not contain very much suspended matter (1.54%), and was not particularly well graded. It ranked fourth in strength; just below the 103 and 104 sands, testing 242 pounds per square inch.

The nature of the grains of the sand has considerable effect on the strength of the mortar. If they are hard, the break occurs in the cement; if poor material, the grains themselves break, thus affecting the strength of the mortar. The Joliet sand was of the last mentioned variety, and this probably contributed in part to its mortar being so low in strength. In contrast to this, the East St. Louis sand is of very good, hard

material, which had an effect in making it the strongest mortar.

Standard specifications in general require that the sand shall be clean, sharp, and well graded. The tests conducted bear out some of these requirements. Cleanness is essential. Sharpness has in general been considered as sharp edges and not round. An examination of these sands shows that the sands making the best mortars had rough surfaces, and some were quite rounded when considered as a whole; i.e. were not sharp. (No's. 51, 103 and 104).

Fuller and Thompson have found that the ideal sieve analysis curve for a mortar mixture approximates a parabola. Confusion often arises by considering this as the ideal curve for the sand, whereas it is for the sand and cement together. Other investigations indicate that the ideal curve for the sand alone ~~considered above~~ is a straight line, and this ideal line has been used here. No's. 103 and 104 sands bear out this statement. They approach this ideal grading quite closely, and although comparatively dirty, are very good sands from the standpoint of tensile strength.

Hence the requirements for a good sand are cleanness, rough surfaces and a uniform grading of grains.

DESCRIPTION OF TABLES.

Table I gives the tensile strength of the different mortars at the different ages with an average of each age for each sand. It is of the usual type of table and needs no further explanation.

Table II gives the percent of suspended matter in each sand as well as the percent by weight of each sand passing the different sieve numbers. The sieves are standard sieves and the number gives the number of openings to the inch from which the diameter of the grains can be found if desired.

The sieve analysis curves give the actual grading and the ideal uniform grading of the sands, using the diameter of opening as ordinates and the percentage by weight passing the different sieves as abscissas.

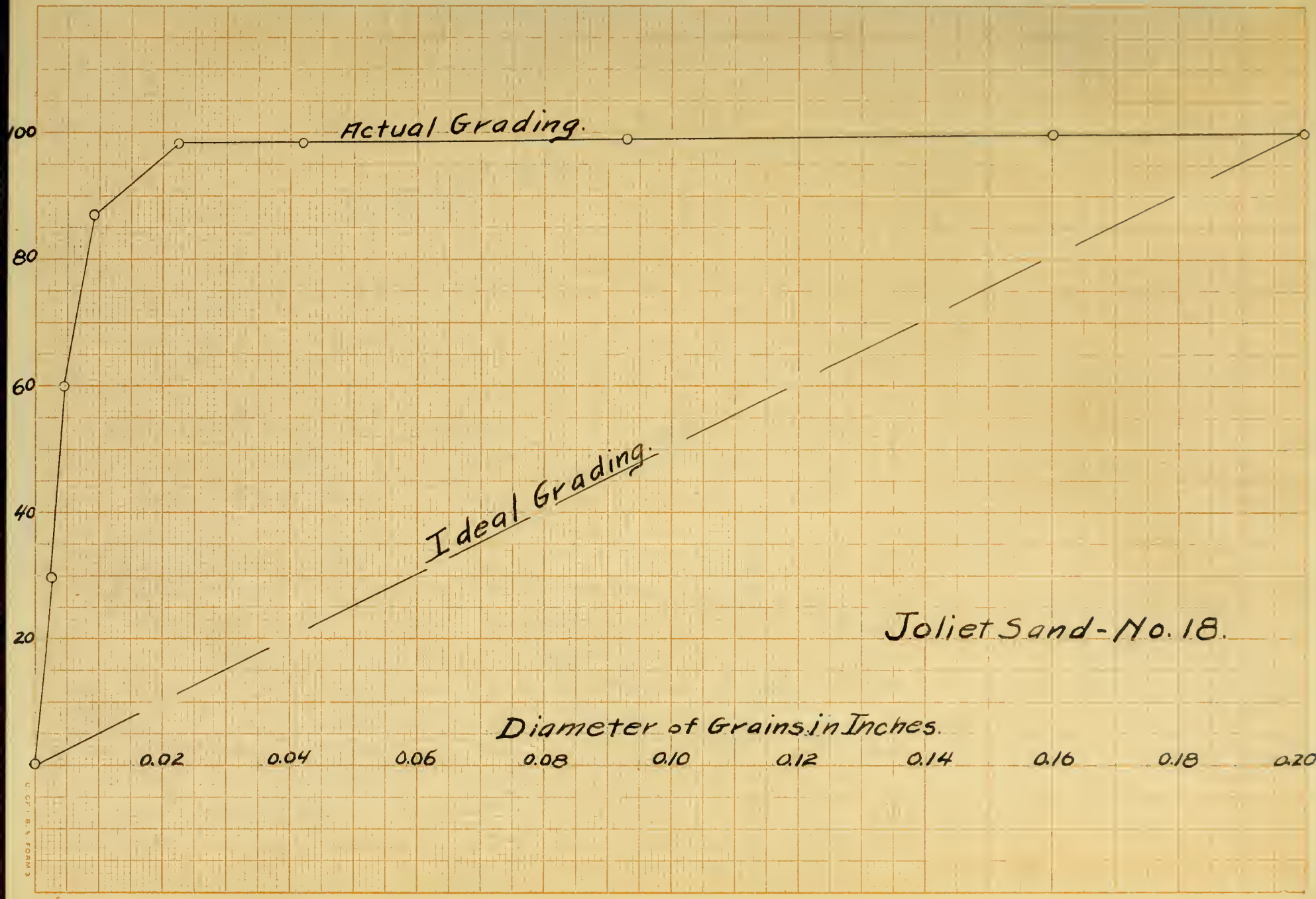
TABLE I

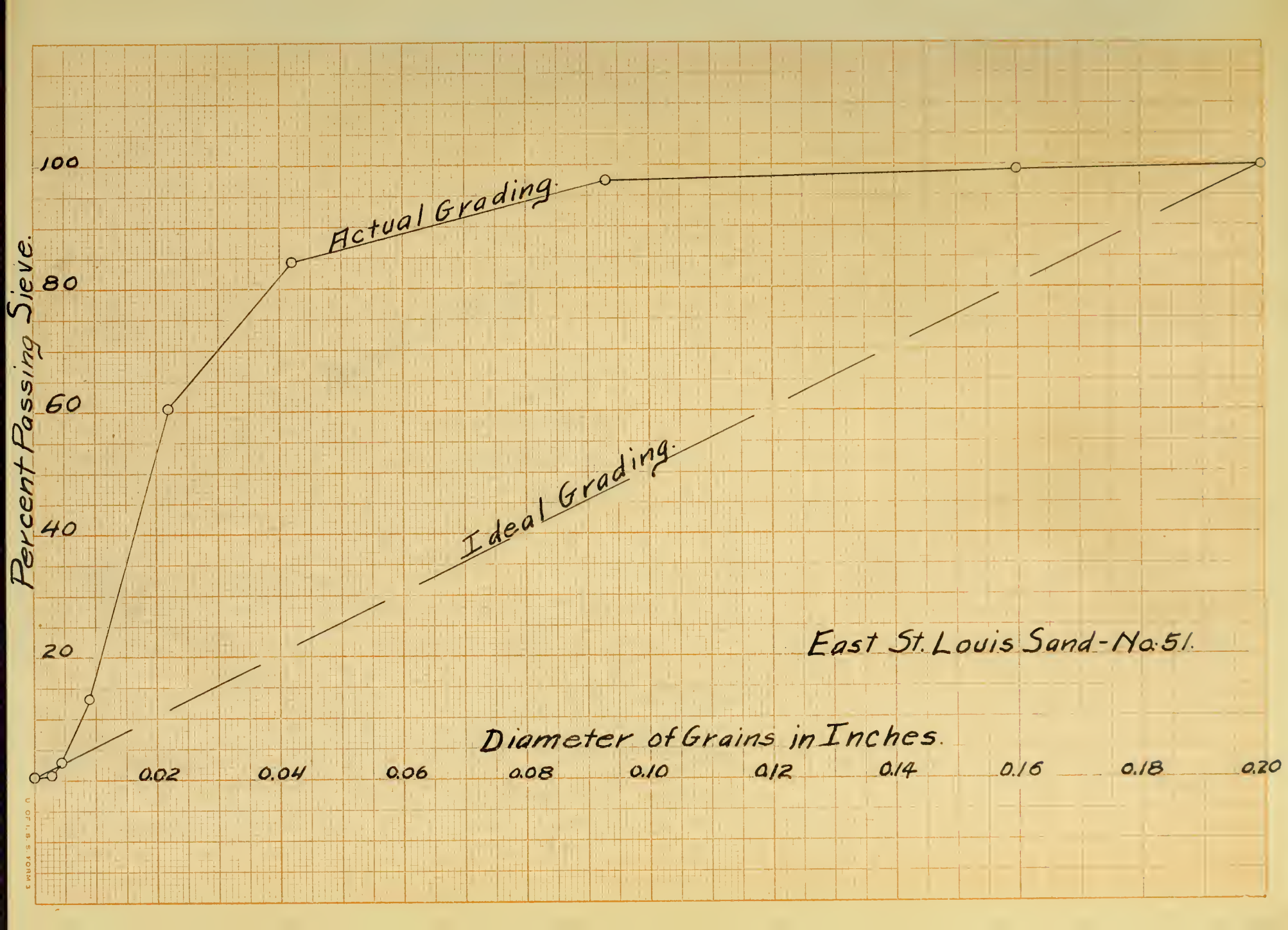
No. of Sand.	Name of Sand.	Age. Days.	Tensile Strength-lbs. per sq. in. Individual Briquettes						Ave.
N	Chicago "A.A." Cement	7	700	710	690	745	740	705	715
		28	795	755	845	785	765	800	791
		90	915	910	875	890	880	770*	894
5	Ottawa Standard	7	190	210	190	215	200	190	199
		28	330	285	295	320	295	320	307
		90	355	350	360	350	345	350	352
18	Joliet.	7	115	100	100	110	100	105	105
		28	145	140	145	145	130	140	141
		90	170	160	175	160	165	160	165
51	East St. Louis.	7	190	175	180	170	190	185	182
		28	245	240	230	225	235	235	235
		90	270	285	275	265	270	275	273
101	Morris - Griggs.	7	170	170	175	190	160	170	173
		28	195	185	195	205	210	195	198
		90	235	245	270	220	230	250	242
102	Morris - Peacock.	7	130	110	110	130	90*	120	120
		28	150	145	140	150	140	155	147
		90	205	215	200	195	195	200	202
103	Morris - Nichols	7	155	165	180	200	170	180	175
		28	200	195	225	230	230	220	217
		90	245	235	260	300	260	240	257
104	Morris - Braun.	7	170	150*	180	170	185	190	179
		28	190	195	200	240	200	260	214
		90	260	230	260	230	290	265	256

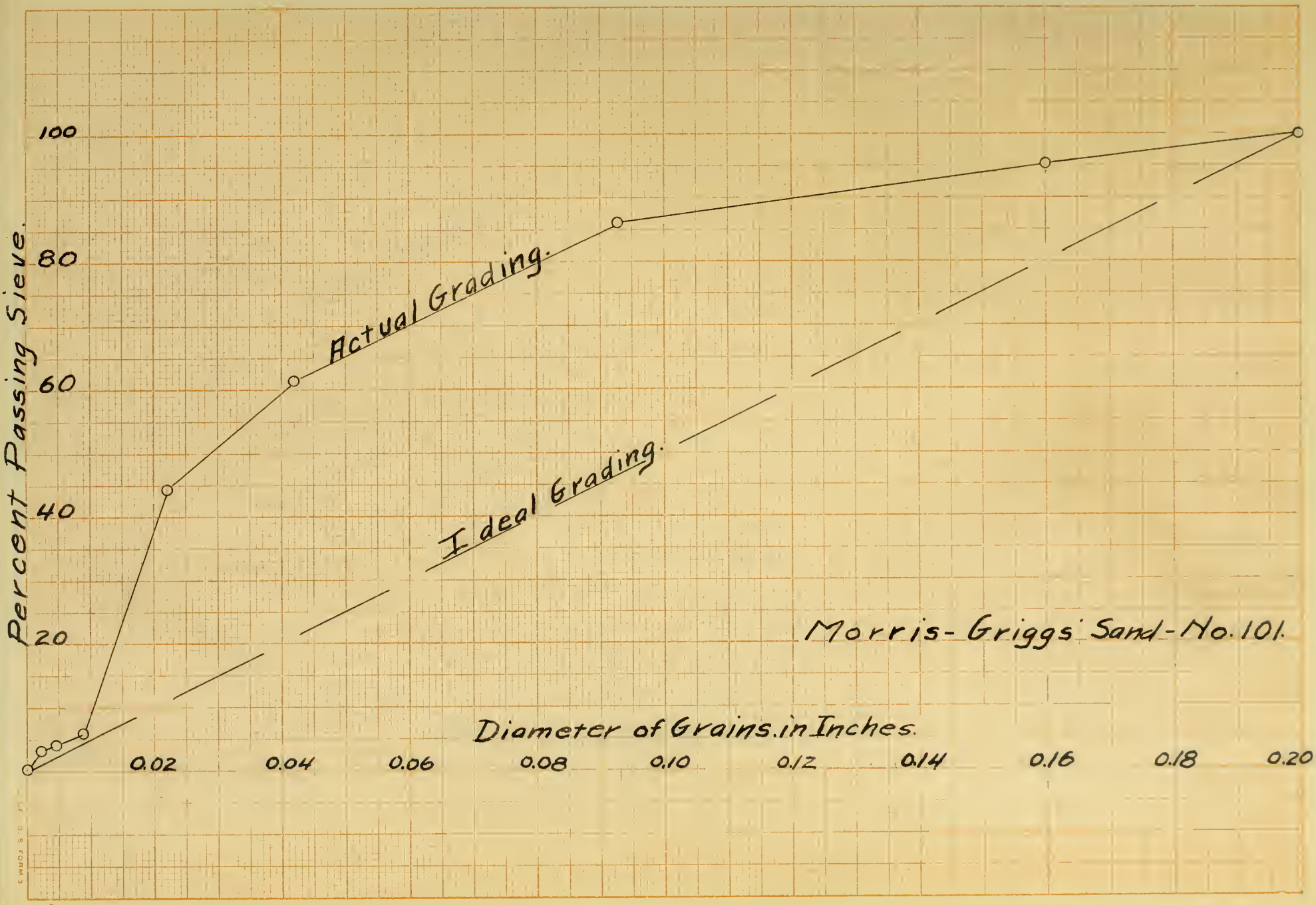
* = Bad break - Thrown out.

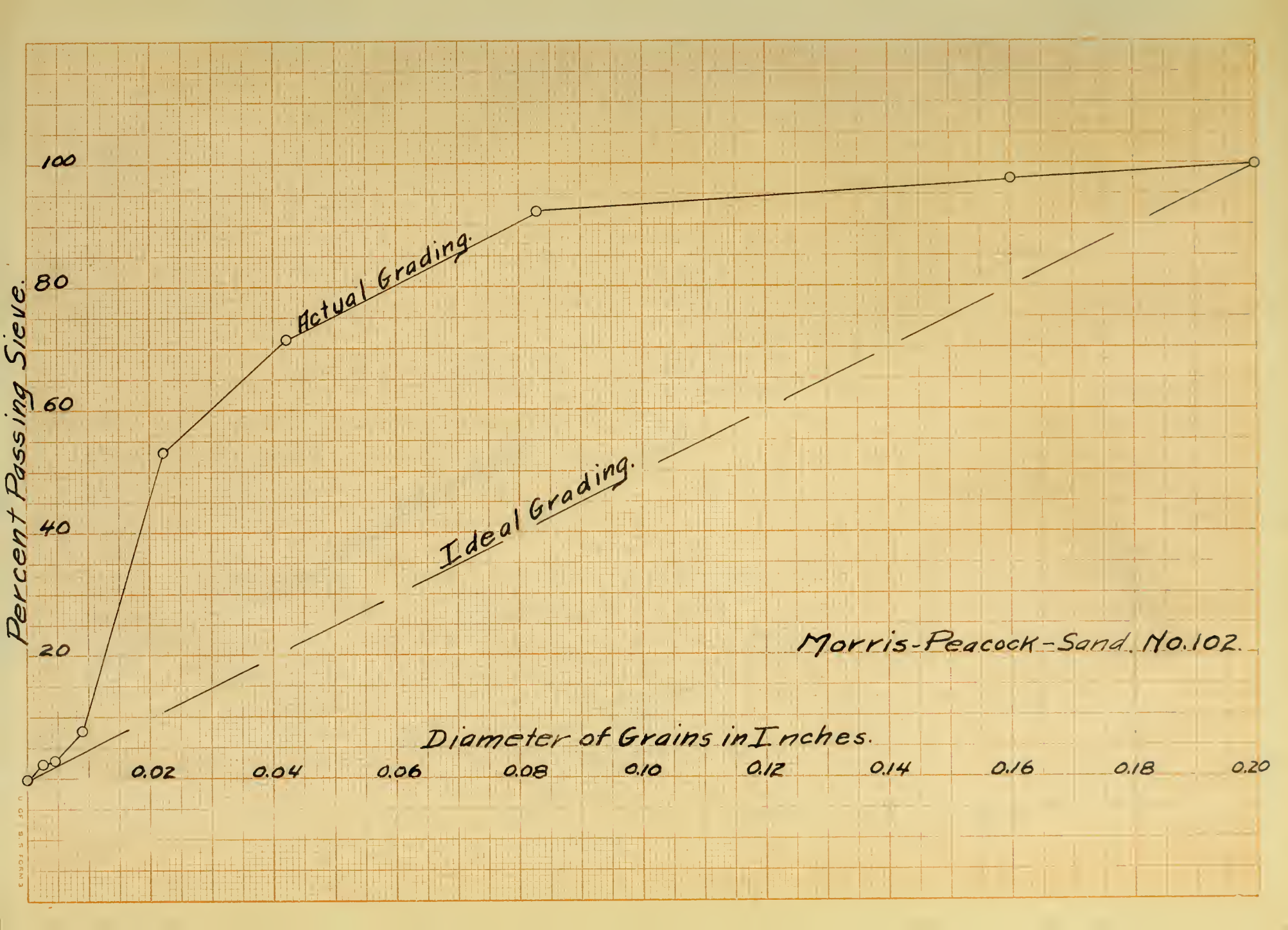
TABLE II

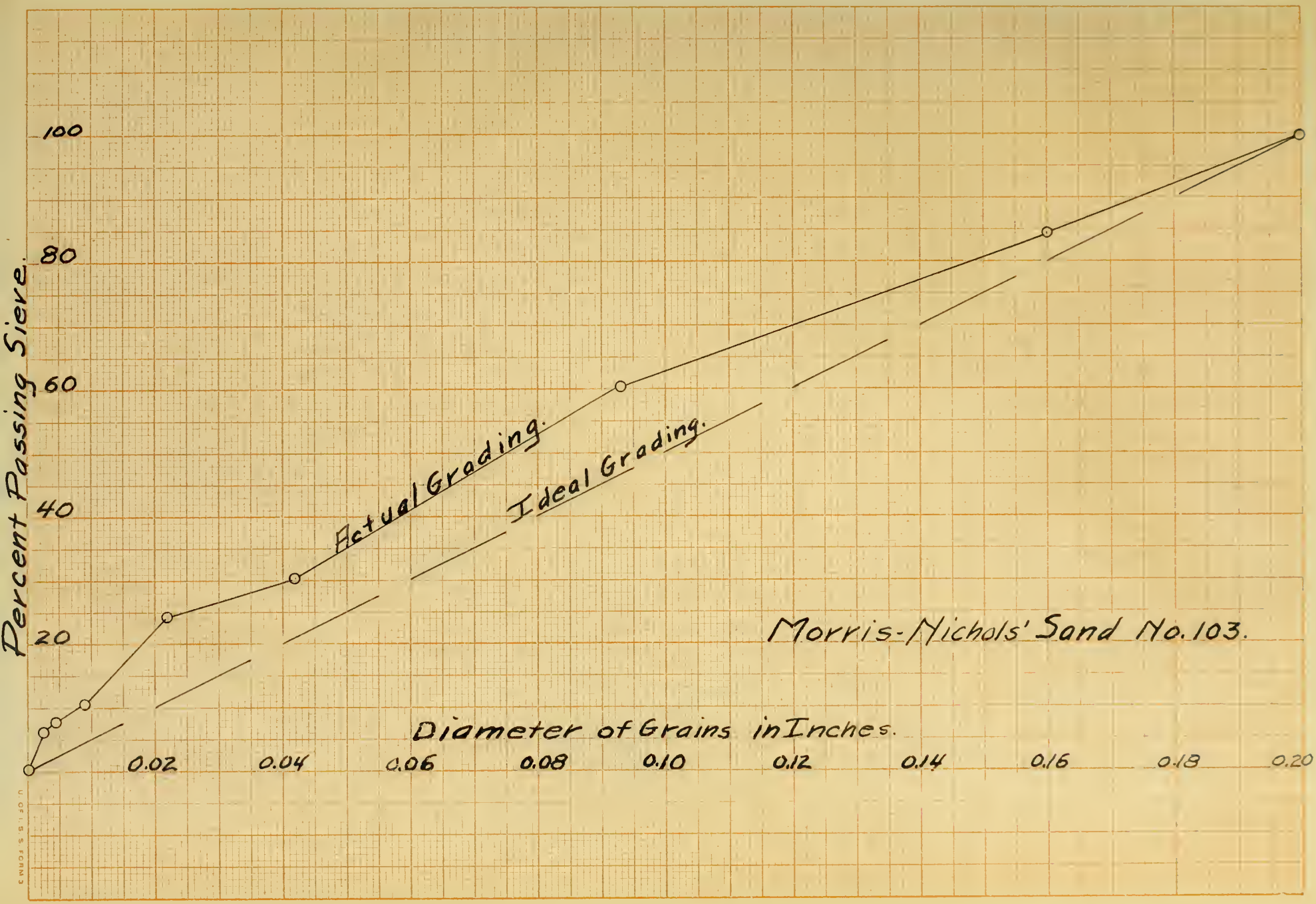
Sample No.	Name	Percent Suspended Matter	Percent by Weight (gr.) passing Sieve No.						
			200	100	60	30	16	8	5
18	Joliet	9.5	29.64	60.74	87.14	98.84	99.64	99.94	99.99
51	E. St. Louis.	Trace	0.98	2.98	13.12	60.58	84.92	98.02	99.42
101	Morris (Griggs)	1.54	2.98	3.80	6.10	44.02	61.59	86.38	95.52
102	Morris (Peacock)	1.50	2.11	2.71	7.81	53.31	71.95	92.52	97.45
103	Morris (Nichols)	4.01	6.58	7.94	10.84	24.58	30.18	60.48	84.45
104	Morris (Braun.)	4.25	5.84.	6.82	8.90	23.67	29.28	58.22	80.52

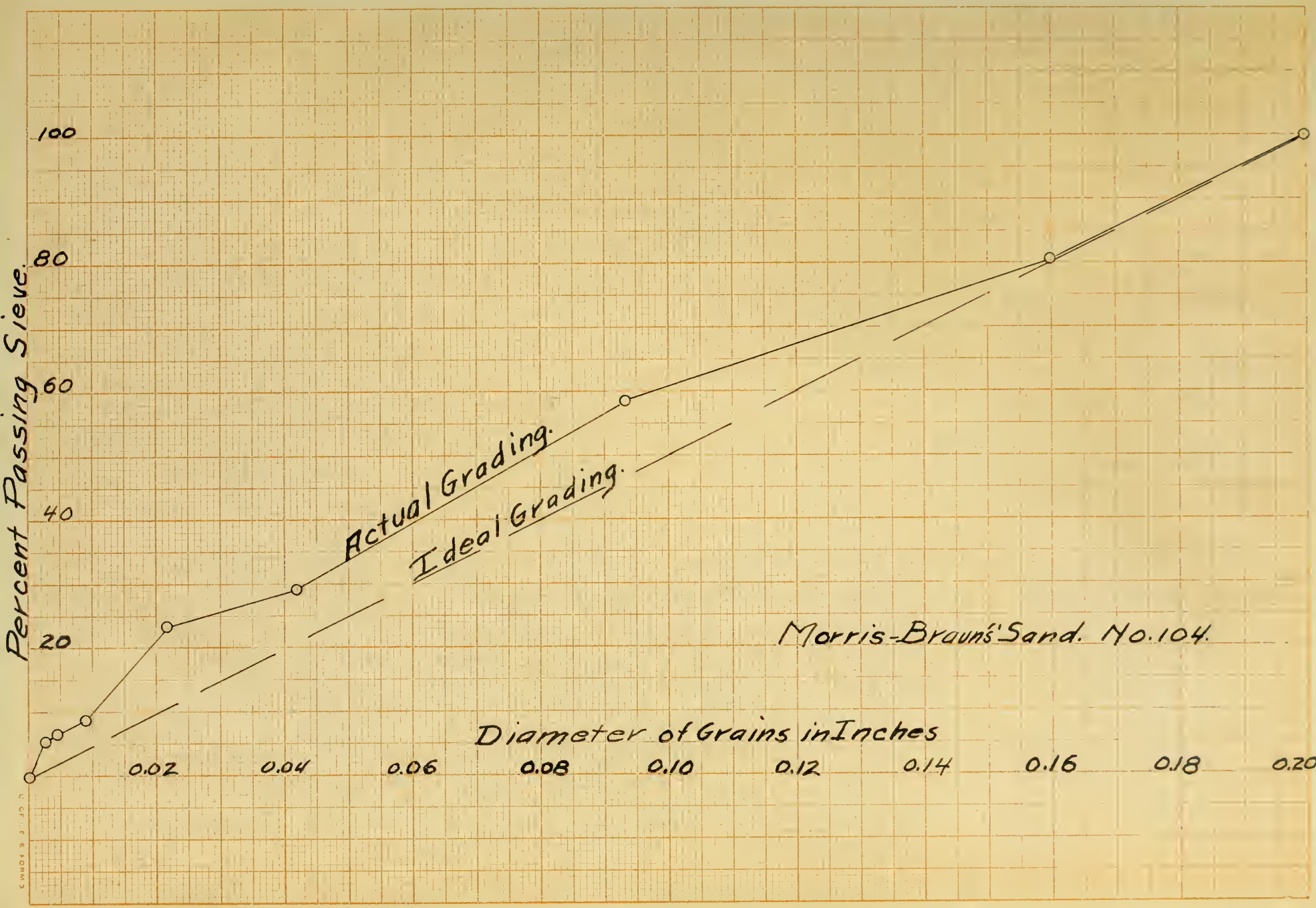

Actual Grading.
Ideal Grading.
Joliet Sand - No. 18.
Diameter of Grains in Inches.
100
80
60
40
20
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20


Percent Passing Sieve.
100
80
60
40
20
Actual Grading.
Ideal Grading.
East St. Louis Sand - No. 51.
Diameter of Grains in Inches.
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20


Percent Passing Sieve.
100
80
60
40
20
Actual Grading.
Ideal Grading.
Morris-Griggs Sand-No. 101.
Diameter of Grains in Inches.
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20


Percent Passing Sieve.
100
80
60
40
20
Actual Grading.
Ideal Grading.
Morris-Peacock-Sand. No.102.
Diameter of Grains in Inches.
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20


Percent Passing Sieve.
100
80
60
40
20
Actual Grading.
Ideal Grading.
Morris-Nichols' Sand No. 103.
Diameter of Grains in Inches.
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20


Percent Passing Sieve.
100
80
60
40
20
Actual Grading.
Ideal Grading.
Morris-Brauns' Sand. No. 104.
Diameter of Grains in Inches
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20